Geophysical Monitoring of Amendment Distribution and Reactivity During a Cr(VI) Bioreduction Experiment at the Hanford 100H Site

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RESEARCH OBJECTIVES

The efficacy of *in situ* contaminated-groundwater remediation, using the injection of chemical or biological amendments, depends on the ability to control their distribution within contaminated heterogeneous media. However, understanding how amendments are distributed in natural subsurface systems is difficult to ascertain using conventional (wellbore) characterization techniques, which often sample only a very localized area. In this study, we explore the use of time-lapse geophysical data for imaging amendment distribution as a function of time and heterogeneity. The geophysical research was performed as part of a Cr(VI) bioreduction experiment at the Hanford 100H Site in Washington, where Hydrogen Release Compound (HRC^{TM}; a slow-release polylactate amendment, is being used to reduce Cr(VI) into insoluble Cr(III) complexes. Hazen, et al. (2005; this volume) provide more details on the Cr(VI) bioreduction study.

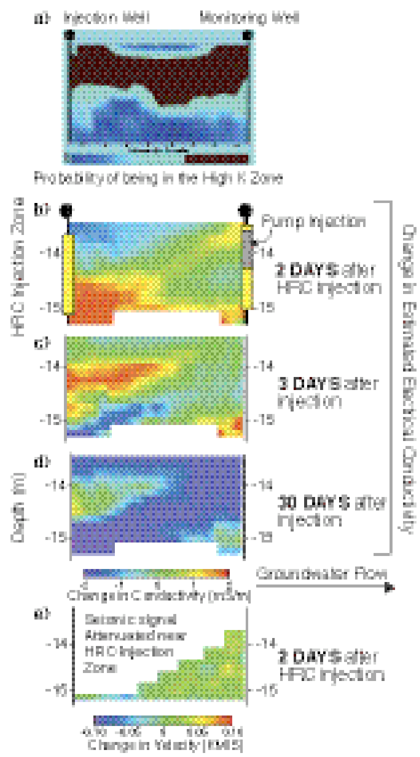

Figure 1. Estimates obtained using geophysical tomographic data: (a) probability of being in a high conductivity zone where black indicates higher hydraulic conductivity; changes in electrical conductivity, (b) 2 days after HRC injection, (c) 3 days after injection, and (d) 30 days after injection; (d) changes in seismic velocity 2 days after HRC injection.

APPROACH

These estimates were determined using seismic and radar crosshole data sets (collected before the injection experiment) with wellbore flowmeter data in a discriminant analysis technique. In August 2004, HRC was injected through the injection well into a Hanford sand/gravel saturated aquifer. Pumping was initiated simultaneously to "pull" the HRC products towards the downgradient monitoring well. Cross-borehole field seismic and radar tomographic data were collected during and subsequent to amendment injection, and were then compared with those data acquired prior to the injection. Geophysical data were also compared with the results of analytical analyses of water samples collected from both wells. Because the HRC and its byproducts are likely to change the electrical conductivity of porous solution, radar tomographic amplitude and velocity data were used to estimate the electrical conductivity changes between the injection and pumping wells.

ACCOMPLISHMENTS

Figure 1a depicts the zonation of hydraulic conductivity of the Hanford formation. Figure 1b indicates the initial increase in the estimated electrical conductivity near the base of the injection interval, which was likely caused by the release of the lactic acid upon hydration of the HRC in groundwater. Figure 1c demonstrates that after 3 days, the effect of pumping from the monitoring well pulled the lactic acid into the higher hydraulic conductivity zone. After 30 days, while the electrical conductivity remained practically the same near the injection well, it decreased (blue areas in Figure 1d) downgradient from the injection well. We hypothesize that this change is likely associated with formation of precipitates. HRC injection caused the seismic response to completely attenuate immediately after the HRC injection (Figure 1e). The field-scale geophysical responses to the HRC injection agree with the results of observations conducted during a series of laboratory controlled HRC-injection and geophysical monitoring experiments.

SIGNIFICANCE OF FINDINGS

The high-resolution, field-scale, cross-borehole geophysical (seismic and radar) measurements hold significant potential for imaging the spatial distribution of lactate-based amendments in heterogeneous sediments, and may be useful for detecting chemical transformations (such as precipitates) of metals. These results also indicate the importance of heterogeneity in controlling amendment distribution. Continuation of this research is necessary to further explore the concept of using geophysical techniques for assessing the remediation efficacy of contaminated sites.

RELATED WEBSITE

http://esd.lbl.gov/ERT/hanford100h/

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